IX. *Some account of the feet of those animals whose progressive motion can be carried on in opposition to gravity.* By Sir Everard Home, *Bart. V.P.R.S.*

Read February 22, 1816.

The house-fly, as is well known, is capable of walking upon the ceilings of rooms, in which situation its body is not supported on the legs; but the principle, by which it is enabled to do so, has never been satisfactorily explained, owing to the animal being too small for the feet to be submitted to anatomical investigation.

I was not aware that any animal of a much larger size was endowed by nature with a power at all similar, so as to admit of this very curious principle being investigated, till Sir Joseph Banks, a few months ago, mentioned that the Lacerta Gecko, a native of the island of Java, comes out of an evening, from the roofs of the houses, and walks down the smooth hard polished chinam walls, in search of the flies that settle upon them, which are its natural food, and then runs up again to the roof of the house. Sir Joseph Banks, while at Batavia, amused himself in catching the Lacerta Gecko, by standing close to the wall, at some distance from the animal, with a long flattened pole, which being made suddenly to scrape the surface of the wall, knocked the animal down.

He has procured for me a specimen of a very large size,

weighing five ounces three quarters, avoirdupoise weight, which has enabled me to ascertain the peculiar mechanism by which the feet of this animal can keep their hold of a smooth hard perpendicular wall, and carry up so large a weight as that of its body.

The foot of the Gecko has five toes, at the end of each of which, except the thumb, is a very sharp claw much curved; on the under surface of each toe are sixteen transverse slits, leading to so many cavities or pockets, the depth of which is nearly equal to the length of the slit that forms the orifice; they all open forwards, and the external edge of each opening is serrated, like the teeth of a small-toothed comb. The cavities, or pockets, are lined with a cuticle, and the serrated edges are covered with it. On each side of the bones of the toe, which are three in number, is situated a large muscle of an oval form; its origin is at the tarsus, the fleshy portion extends to the end of the first bone of the toe, and the tendons of both are continued on to the claw, which is moved by these muscles. From the tendons of these large muscles, two sets of smaller muscles originate; one pair of which is lost upon the posterior surface of each of the cavities, or pockets, that lie immediately over them.

The large muscles, by their contraction, draw down the claw, and necessarily put the small muscles that go off from the tendons of the larger upon the stretch, so that under such circumstances they act to a greater advantage. When these contract, they open the orifices of the cavities, or pockets, to which they belong, and turn down the serrated edge upon the surface on which the animal stands.

On each side of the toes there is a loose fold of skin, giving

the toes an unusual breadth. The cavities, or pockets, which have been described, and the muscles connected to them, form the only peculiarities in the foot of this particular species of lizard.

Upon examining attentively the under surfaces of the toes, when the cavities, or pockets, are closed, they bear a considerable resemblance to the surface of that portion of the head of the Echineis Remora, or sucking-fish, by which it attaches itself to the shark, or the bottom of ships; it therefore suggested itself, that much useful information, applicable to the present subject, might be derived from the examination of such an apparatus, more especially as the parts of which it is composed, are so much larger in size, and more within the the reach of examination.

The surface on the top of the head of the Echineis Remora, fitted for adhesion, is of an oval form, and bears a considerable proportion to the size of the whole animal; it is surrounded by a broad, loose, moveable edge, capable of applying itself closely to the surface on which it is placed.

The apparatus itself consists of two rows of cartilaginous plates connected by one edge to the surface on which they are placed; the other, which is external, having the same serrated appearance described in the mechanism of the toes of the Lacerta Gecko. These plates are capable of being raised and depressed at the will of the animal, there being muscles upon the skull adapted to that purpose. The two rows are separated by a thin ligamentous partition, and the only apparent reason for their being so divided, is to render them more manageable, as the two portions in every respect resemble one another.

It is evident, that when the external edge of this apparatus is closely applied to any surface, and the cartilaginous plates are raised up, the interstices must become so many vacua, and the serrated edge of each plate will keep a sufficient hold of the substance on which it rests, to retain it in that position, assisted by the pressure of the surrounding water, without a continuance of muscular exertion.

It thus appears, that the adhesion of the Echineis Remora is produced by so many vacua being formed by an apparatus worked by the voluntary muscles of the animal, and the pressure of the surrounding water.

From the similarity of the mechanism of the under surface of the toes of the Lacerta Gecko, there can be no doubt, that the purpose to which it is applied, is the same; but as in the one case, the adhesion is to take place under water, and is to continue for longer periods, the means are more simple. In the other, where the mechanism is to be employed in air, under greater disadvantages with respect to gravity, and is to last for very short periods, and then immediately afterwards be renewed, a more delicate structure of parts, a greater proportional depth of cavities, and a more complex muscular structure becomes necessary.

Having ascertained the principle on which an animal of so large a size as the Lacerta Gecko, is enabled to support itself in its progressive motion against gravity, I felt myself more competent to enquire into the mechanism by which the common fly is enabled, with so much facility, to support itself in still more disadvantageous situations.

In the natural size the feet of the fly are so small, that nothing can be determined respecting them; and when highly

magnified, such is the liability to error, that any person with a preconceived opinion becomes an improper observer of the appearances that are represented. From this consideration, I have not examined them myself, but have rather chosen to refer to the representation of their structure taken by others. Mr. GEORGE ADAMS, mathematical and optical instrument maker, in Fleet-street, London, in the year 1746, published a plate representing the appearance of the fly's foot when highly magnified. This figure will be found at the end of the paper. His account of the uses of the different parts is by no means satisfactory, but he concludes it by saying, "That the fly is enabled to walk on glass, proceeds partly from a ruggedness of the surface, or a kind of tarnish, or dirty, smoaky substance adhering to the surface of that very hard body; and though the pointed parts (*of the fly's foot*) cannot penetrate, yet they may find pores enough in the tarnish, or at least make them. This structure Mr. HOOK surveyed with great diligence, because he could not comprehend, that if there was any such glutinous matter in those supposed sponges (as most that have observed that object in a microscope have believed), how the fly could so readily unglew and loosen its feet; and also because he had found no other creature any ways like it." JEAN CHRISTOFLE KELLER, painter at Nuremberg, made a drawing of the fly's foot in a highly magnified state, which was published in 1766. The author of the publication to which these plates are annexed, whose name is not mentioned, takes some pains to refute the opinion of M. REAUMUR, who calls the surfaces of the soles of the fly's feet *pelotes*, or balls, which this author ascribes to M. REAUMUR not having seen them sufficiently distinctly. This author says, that they are not balls,

but concave surfaces, as KELLER represents them; a copy of which representation is annexed.

Although the author states them to be concave surfaces, he says that they are only used when the fly moves horizontally; but when it moves perpendicularly, or upon the ceiling, they are turned up out of the way; and the progressive motion is carried on by fixing the crotchets into the irregularities of the surface on which the fly treads, whether glass, porcelain, or any other substance. It will, however, scarcely be doubted, from the preceding facts, that these concave surfaces are employed to form vacua, which enable the fly to move under such disadvantageous circumstances upon the same principle as the Lacerta Gecko.

EXPLANATION OF PLATES.

PLATE VII.

The external form of the Lacerta Gecko.

PLATE VIII.

Fig. 1. The under surface of one of the toes of the Lacerta Gecko of the natural size.

Fig. 2. A toe dissected to show the appearance of the pockets on its under surface, their serrated cuticular edge, the depth of the pockets, and the small muscles by which they are drawn open, the parts much magnified.

aa The two muscles which lie on the sides of the bones of the toe, with their tendons inserted into the last bone close to the root of the claw. From these tendons the muscles belonging to the pocket go off.

Fig. 3. The upper surface of the head of the Echineis Remora, to show the apparatus by which the animal has a

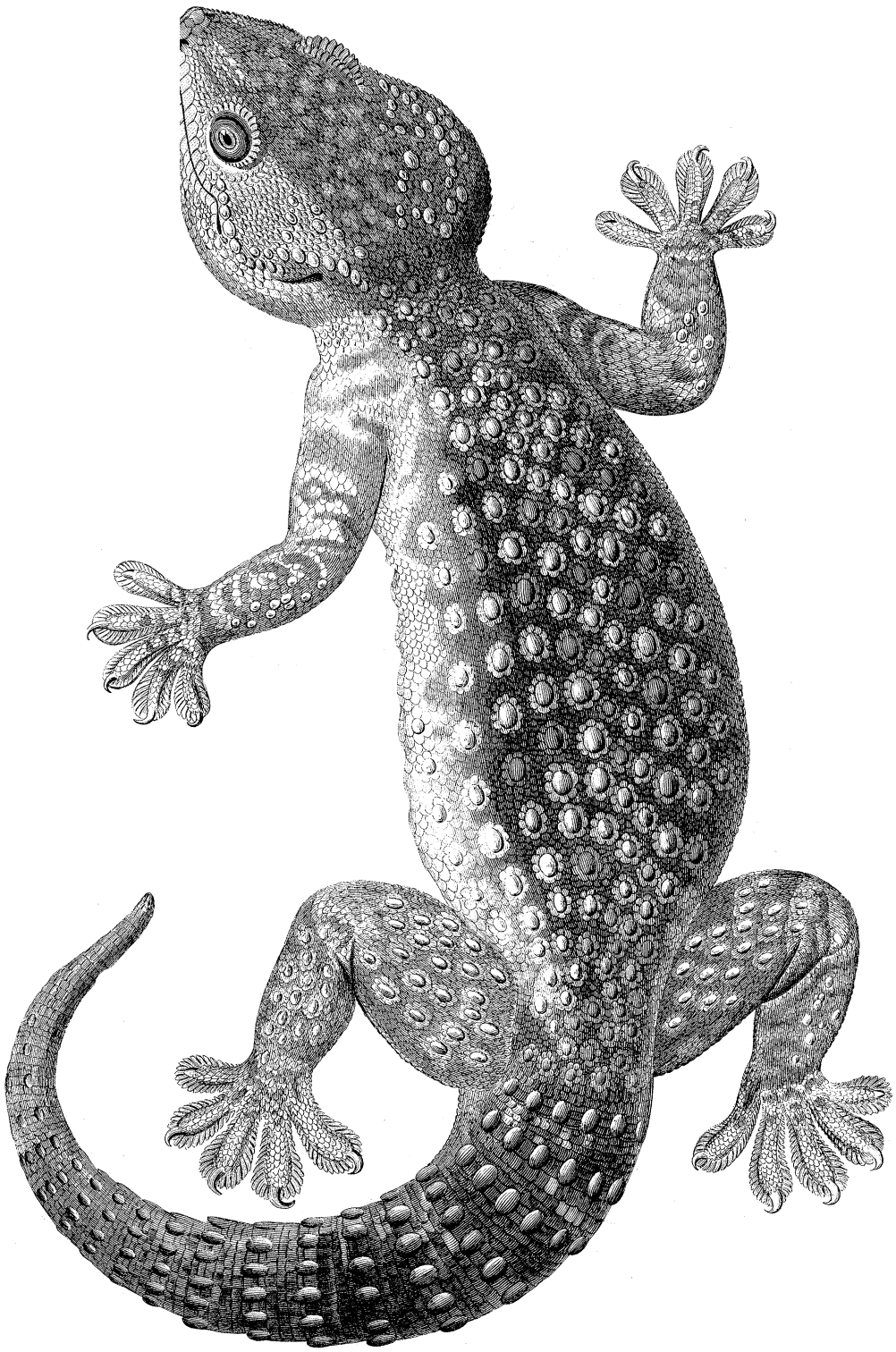

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Fig. 1.

Fig. 2

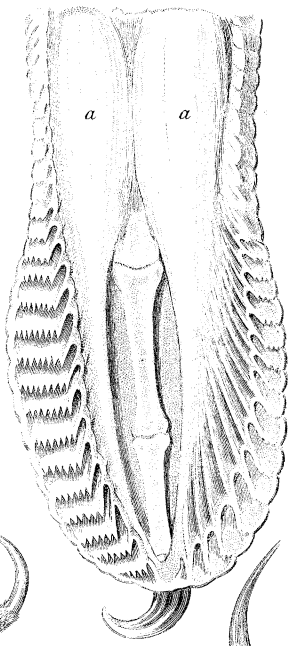


Fig. 4.

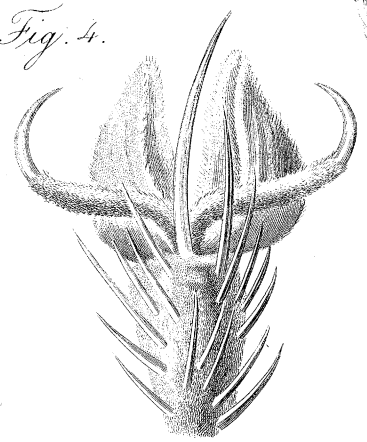
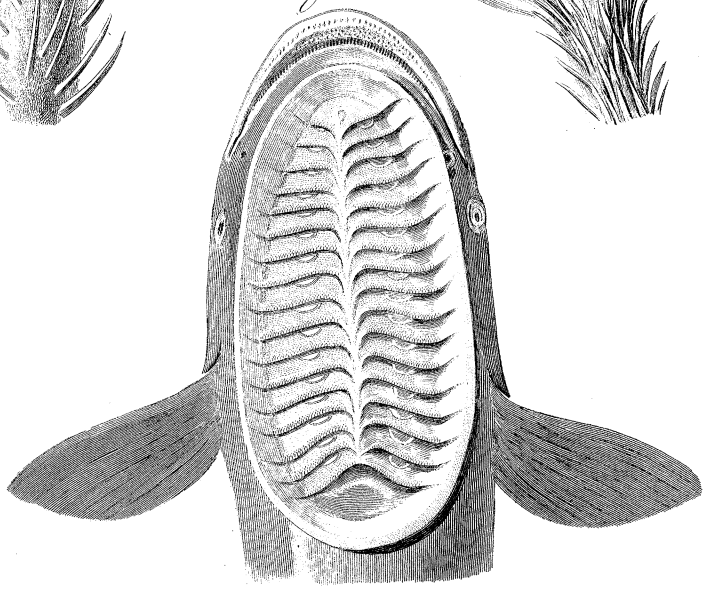


Fig. 5.

Fig. 3.



power of adhering to the surface on which it is placed, of the natural size. One half of this apparatus has the cartilaginous plates closed, the other open.

Fig. 4. The under surface of the foot of the house-fly highly magnified, showing the two concavities by which the foot attaches itself to the surface on which it is placed, and two claws for laying hold. Copied from a plate by G. ADAMS, published in 1746.

Fig. 5. Another view of the same parts copied from a plate published in 1766, taken from a drawing of CHRISTOFLE KELLER, painter at Nuremberg.